variables, the phase law, gaseous systems, dissociation, and dilute solutions.

As is well known to specialists in thermodynamics, Prof. Planck, instead of using the thermodynamic potentials of the majority of writers, prefers to deduce the conditions of equilibrium from the study of the function

$$\frac{(\text{energy})-(\text{temp.})(\text{entropy})+(\text{pressure})(\text{vol.})}{-(\text{temperature})}$$

i.e. the ordinary thermodynamic potential corresponding to temperature and pressure as independent variables, divided by temperature and reversed in sign. While this function has not the advantage of being an exact analogue of the potential functions in statics, the differential coefficients of which with respect to the position-coordinates are equal to the corresponding generalised force-components, its introduction undoubtedly serves to bring the conditions of equilibrium and stability of thermodynamic systems into closer connection with the entropy properties. We should prefer to see the principle of degradation of energy instead of the entropy principle adopted as the basis of thermodynamics. This would obviate the introduction of Planck's function, the ordinary thermodynamic potentials taking its place. The compensating drawback is that the available energy of a system is not a definite measurable quantity, but is dependent on the surrounding media.

The method of introducing such notions as temperature and entropy cannot be regarded as satisfactory. We find in chapter i. the usual juggling with the terms "perfect gas" and "absolute temperature." Thus absolute temperature is defined in § 9 by the expansion of gases, while in § 24 these gases are shown to obey laws which are not rigorously consistent with this definition of temperature. The term "perfect gas" is introduced in a vague sort of way in this chapter, but without sufficiently definite statements being made as to what is a perfect gas and what is not. To define absolute temperature by means of a perfect gas and then define a perfect gas by means of its laws of expansion referred to absolute temperature is merely working round in a circle.

Moreover, the *entropy* of unit mass of a substance is defined, in the first instance, by the formula

$$\phi = c_v \log \theta + \mathrm{R}/m \log v + \text{const.},$$

applicable to the case of a perfect gas. This definition is suggestive of the definitions of *pole* and *polar* given in many text-books, according to which "the line $xx'+yy'=c^2$ is called the polar of the point $x'y'$ with respect to the circle $x^2+y^2=c^2$." But while the effects of the latter definitions are made patent by the absurd answers sent up by a large proportion of examination candidates to pole and polar questions on (*e.g.*) a so-called "general conic," opportunities at present do not occur so frequently in this country of testing how an average student, after reading such a treatment, would "define entropy." To define a physical quantity in the first instance by means of its value in a particular case, when the definition is not valid in the more general case, is certain to be misleading, and no amount of subsequent discussion, such as Prof. Planck admittedly gives, can set matters right. We have marked instances of the same thing in the old-fashioned treatment of electrostatics and magnetism, in which bodies were stated without reservation to attract one another according to the law of the inverse square, and when dielectrics were subsequently introduced there seemed something wrong about the whole theory which the writer of this review never cleared up until after his undergraduate days.

From this it will be seen that if Prof. Planck's treatise is no worse than many others on the same subject, it is in some essential points no better. It is a book which will be read with great interest by the physicist, generally in conjunction with other books on the same subject, but it is scarcely the book for an engineer to refer to for information on the nature of "entropy." G. H. B.

GEOGRAPHY AS A SCIENCE.

The Teaching of Geography. By Prof. J. W. Gregory D.Sc., F.R.S. (Melbourne and London: Whitcombe and Tombs, Ltd.)

The Austral Geographies. Classes ii., iii., iv., v. and vi. Same Author and Publishers.

PROF. J. W. GREGORY is taking an active part in the promotion of sound geographical instruction in the land of his adoption. In a lecture recently published he sets forth the scope of geography and the way in which it should be applied to education. In a series of school-books he shows practically how he would do this for Australian children.

For Prof. Gregory geography is not a science, but a branch of knowledge which may be taught scientifically—its subject-matter is "description drawn from observation; it is not a search for underlying principles, nor a discovery of ultimate causes." In applying this descriptive knowledge to education Prof. Gregory points out that descriptions must glide into explanations and awaken interests which cannot be satisfied without understanding this world of ours. The geographer must not hesitate to borrow from literature, history, or science that which will make his appeal to his pupil's imaginations most stimulating. Prof. Gregory's scheme, as developed in the "Austral Geographies," is to begin with a plan of table, school-room, school, &c., leading to a map, directions, seasons, clouds, rivers, land forms (in the first stage these are definitions), a brief description of Victoria, and a few lines about other Australian States and the continents. In each succeeding book some sections of physiography are discussed, and are followed by a description of (*a*) Australasia in Class iii., (*b*) the continents ending with Australia in Class iv., (*c*) the British Empire in Class v., (*d*) Europe, U.S.A., Japan, Pacific Archipelagoes, and world trade routes in Class vi. Both the physiographical and the geographical parts are so planned that each year more advanced conceptions, as well as greater details, are given. The books, in the hands of a good teacher who applies the hints given in Prof. Gregory's lecture, should yield useful results, and teach the pupil much about land forms and climate and descriptive topography.

The physiographical part is the better, but the limitations which Prof. Gregory applies to geography have hampered his treatment of the rest of the book. The land forms (a better term than earth forms) are accurately described, but although in his lecture he vigorously insists on "the fact of facts in geography is the circulation of water by its evaporation from the sea, its movement through the air, as invisible aqueous vapour, its concentration in clouds, and its fall as rain," he practically ignores climate in his descriptions of the different countries. He loses more than half the educational value through this neglect. Climate and configuration are equally indispensable fundamental factors in geography.

We agree with him when he protests against the idea that anthropology, zoology, botany, astronomy and geology are but branches of geography. This is not the geographer's point of view. The misconception is due to the confusion of the old South Kensington physiography—a useful introduction to elementary science, mainly physical, especially in its cosmical and terrestrial aspects—with geography. This physiography, as Prof. Gregory points out in his preface, gave a valuable training to many a teacher of geography, and helped to expel deep-rooted fallacies and misleading expressions which were (and to some extent still are) to be found in many geographical text-books. We fear that Prof. Gregory believes that geography consists of two parts, a physiographical part which is scientific, and a topographical part which is purely descriptive.

We have no wish to undervalue the descriptive aspect of geography, but this does not involve a rejection of geography as a branch of science. Prof. Gregory, and those who think as he does, have not yet shaken off the effects of their own schoolboy experiences. They have not seen the world as composed of a number of very complex associations of rock, water, air, plant, and animal, including man, which may be classified generically and specifically as readily as the organisms which they contain. The aim of the geographer, like that of the botanist or zoologist, is not confined to observing and describing phenomena, but includes comparison, classification and interpretation. It is a science, a science of forms which have not hitherto been generally recognised as such, and the activities within and around them. The educational value of geography is as much in its scientific discipline as in its appeal to the imagination and sympathy. Prof Gregory's books fall short of the ideal in so far as he excludes scientific geography from his descriptive pages. He has not yet recognised these higher groupings of phenomena connected by a specific topography. We venture to think that the first part of the twentieth century will be as noted for the recognition and study of these macro-organisms as the latter part of the nineteenth century was for the recognition and study of micro-organisms, and we believe that the beneficial effect on the body politic will be as great in the one case as it has been in the case of the individual in the other.

A. J. HERBERTSON.

LIQUID FUEL.

Liquid Fuel and its Combustion. By W. H. Booth. Pp. xx+411. (Westminster: Archibald Constable and Co., Ltd., 1903.) Price 24*s.* net.

IN view of the great interest taken at the present time in the subject of liquid fuel and the part it is likely to play in the future, Mr. Booth's book comes as a welcome record of the work done in the past, and would have been enormously enhanced in value had the references to the original papers been fully quoted.

The first part of the work deals with the general properties and advantages of liquid fuel, and a good deal of this portion of the book might with advantage be omitted in a future edition, as, for instance, the chapter on water, its properties and purification, which are certainly out of place in a book devoted to a special subject and not likely to be used as a manual for boiler practice.

Mr. Booth's ideas on the subject of combustion are open to criticism, as he is evidently a strong believer in the preferential combustion of the hydrogen in hydrocarbons being the cause of the liberation of carbon in the form of smoke and soot when there is insufficient air for complete combustion in the boiler furnace, but a consideration of the actions taking place in a water gas generator may shake his belief in this, as, if at such temperatures any preferential action exists, the fact that steam passed through red-hot carbon yields carbon monoxide, carbon dioxide, and hydrogen would certainly point to carbon and not hydrogen as the element most favoured by the attentions of the oxygen at the temperature of the furnace.

On p. 105 the author breaks into amusing diatribes against the man of science, and comes to the conclusion that "when the most important industrial operations are absolutely neglected by our supposed teachers and leaders of scientific practice, it devolves upon those to whom science is less familiar, but more attractive, to step into the breach." This sentence probably explains a good deal of the vagueness to be found in the author's speculations on liquid and gaseous carbon and solid hydrogen in the portion of the work devoted to calorific value and combustion.

In the second part of the book practical engineering questions are dealt with, such as oil storage, the atomising of oil for combustion, and the work which has been done with liquid fuel, both on the Continent and in America, and here the author is thoroughly at home.

The engineering side of the question is admirably handled, and the collection of data which is given will render this part of the work of exceptional value to those dealing with this important subject.

The chapters on compressed air, flue gas analysis, and calorimeters will be welcome to many practical men, and the appendix is of special value as containing a report of the United States Naval Bureau on tests of liquid fuel for naval purposes.

There is no question that the time has now been reached when the methods of burning liquid fuel are